Machine Learning in Wind Turbine O&M

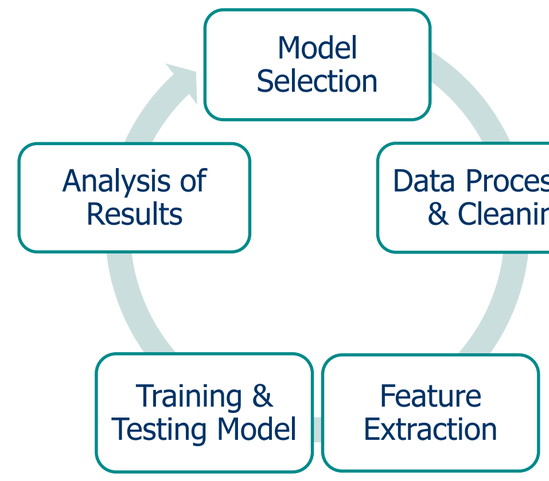
Conor McKinnon, James Carroll, Alasdair McDonald, Sofia Koukoura

Wind & Marine Energy Systems CDT, Rm 3.36, Royal College Building
University of Strathclyde, 204 George Street, Glasgow, G1 1XW

conor.mckinnon@strath.ac.uk

General Approach

My PhD will investigate the use of Machine Learning techniques in various applications within the field of Wind Energy. The general approach to Machine Learning follows the steps shown on the right. Model selection is done through literature review, which depends on the data used. This data is then processed and cleaned, through clustering and removal of outliers. Features are extracted from the data, either from univariate statistics to find the feature with the least variance from the target, or PCA to reduce the number of features to two abstract features with no physical meaning. This data is then used to train and test the model(s). The results produced are then analysed, either using existing alarm data, or through k-folds cross validation. These results can also inform on model selection.



Anomaly Detection

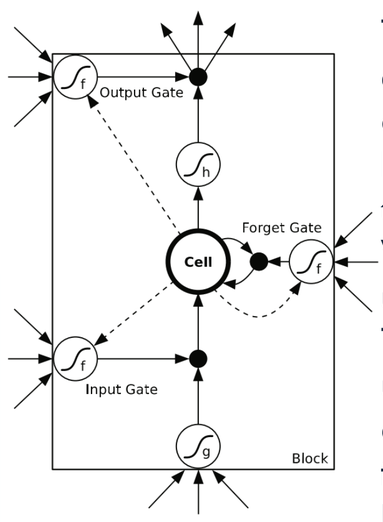
Anomaly detection involves using Machine Learning or Statistical techniques to determine the normal behaviour of the data, and compares new data against said normal to assess whether it is an anomaly or not. Two packages will utilise this method, both for gearbox and pitch/yaw failure prediction. Both of these packages will investigate SCADA date for this analysis.

Oil Analysis

https://www.offshorewind.biz/2014/08/29/exxonmobil-extends-wind-turbine-gearbox-oil-warranty/

This package looks at gearbox failure and remaining useful life classification using oil analysis data. This involves working with Nordex to gather data and obtain oil analysis reports. These data and reports will then be used to both identify, and then classify the failures. The exact method of classification is still to be set, however it will use the general approach discussed above.

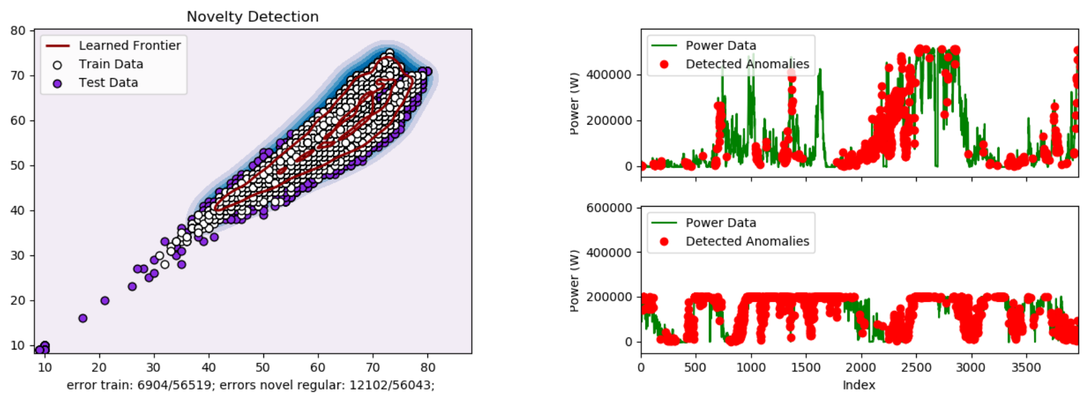
Deep Learning



A. Graves, Supervised Sequence Labelling with Recurrent Neural Networks, J. Kacprzyk, Ed. Springer, 2012. [Online]. Available: https://link.springer.com/content/pdf/10.1007%5C%2F978-3-642-24797-2.pdf

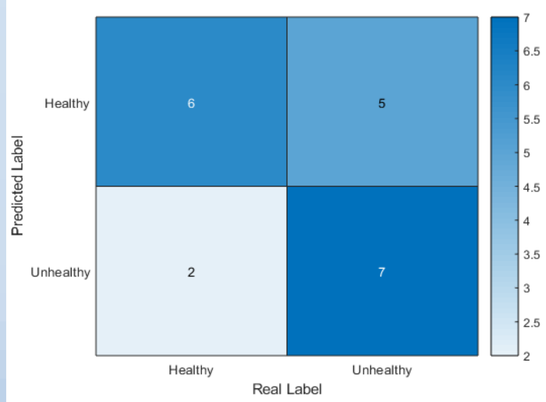
This work package carries on from work done during a Mini Project. This investigates the ability to classify Wind Turbine health using neural networks. This technique was used to try and eliminate the use of feature extraction of high frequency vibration data. In the mini-project it was found that a Long Short-Term Memory Neural Network (LSTM). Left is an image of the neuron from an LSTM.

Anomaly Detection Results



So far I have been exploring the use of One Class Support Vector Machines (OCSVM) to detect anomalies within SCADA data. This is a first foray into the area, with more models to be investigated and compared. The North-West figure shows the detection of anomalies using an OCSVM technique trained on SCADA data from 14 turbines over a month period, one year before failure. This is then tested on data from the same turbines but one month before failure. North-East shows the number of anomalies detected in red, compared to average power in green.

Deep Learning Results



Some results from my work during the Summer of 2018 have been used to highlight the outcome of the deep learning technique. North-West shows the "confusion matrix" of the classifications made by the Recurrent Neural Network used to classify the health of 20 Wind Turbine Gearboxes.

These neural networks still follow the general approach above, barring the feature extraction and data cleaning steps. Future work may be to explore the use of data cleaning, or different networks. This will help to compare different methods of deep learning and aim to improve on the accuracy of the previous models. The findings from the mini-project were from a small sample of vibration data, and ideally this work package will have an order of magnitude more samples to investigate.

EPSRC
Engineering and Physical Sciences Research Council

futureWind 2019 & Marine